COMMUNICATION AND COOPERATION IN A COMMON-POOL RESOURCE
DILEMMA: A FIELD EXPERIMENT

by

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I. INTRODUCTION

One tenet of classical, rational choice theory as used in noncooperative game theory is that all players use the same model of rationality for themselves as well as for all other players. The assumption of homogeneous, self-interested actors helps theorists model how individuals would make choices. One justification for positing homogenous, rational, egoistic actors has been evolutionary theory (Dawkins, 1976). That is, even if individuals tried out different ways of behaving, only those who made decisions consistent with rational egoistic decisions would maximize returns. In a highly competitive environment, those who maximize returns are more likely to survive in the long run. Long ago, Armen Alchian (1950) made a cogent theoretical argument that in a highly competitive market, selection pressure would weed out those market participants who did not maximize profits. Extensive experimental studies of behavior in competitive market settings have supported using the classical, rational choice model as the only model of individual choice needed in this setting to make empirically supported predictions (Smith, 1962; Plott, 1986). Thus, continuing to use the classical model when analyzing competitive markets has both strong theoretical and empirical support.

In the early 1980s, however, Werner Güth and colleagues began a series of experiments on the ultimatum game, which challenged the capability of the classical model to explain behavior in some nonmarket settings (see, for example, Güth, Schmittberger, and Schwarze, 1982; Güth, 1995a). In an ultimatum experiment, a “Proposer” makes a take-it-or-leave-it proposal for how to divide an amount of money and a “Responder” chooses to accept the offer
(in which case the division is made as proposed) or reject the offer (in which case neither of them receives any funds). The game-theoretic prediction is that the Proposer should offer the smallest positive amount and the Responder should accept anything above zero. Nothing could be clearer in theory. Güth and his colleagues, however, found that neither prediction was substantiated in the lab (Güth, 1995a). In experiments that have been replicated multiple times in many countries, Proposers tend to offer between 40 and 60% and Responders tend to reject any offer below 20% (see Tables 2.2 and 2.3 in Camerer, 2003, where data from 15 experiments is summarized).  

Equally dramatic findings have come from experimental studies examining behavior in social dilemmas including public goods (Isaac, McCue, and Plott, 1985; Isaac and Walker, 1988) and common-pool resources (Walker, Gardner, and Ostrom, 1990; Ostrom, Walker, and Gardner, 1992; Casari and Plott, 2003). The theoretical prediction in social dilemma games is that players will not make decisions that would lead to a group optimum. Rather, players are predicted to play strategies leading to a suboptimal Nash equilibrium. Simply allowing the players to communicate with one another without external enforcement of agreements does not change this prediction. Behavior in public good and common-pool resource experiments, however, deviates substantially from the Nash equilibrium strategies when subjects are merely allowed to communicate with one another (Ostrom and Walker, 1991).

Given repeated findings from carefully designed and replicated experiments, multiple scholars have now concluded that the assumption of the classical model about homogeneous, own-payoff maximizing players, cannot explain behavior in a wide variety of nonmarket settings. A substantial number of alternative theories have been proposed to explain these

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1 See also Carpenter and Cardenas (2003) for a further survey of experimental studies of ultimatum, dictator, and trust experiments with nonstudent subjects across several countries and cultures.
findings. Many of the alternatives assume that players take the payoffs made to other players into account (either positively or negatively) in their own utility function (see, for example, Fischbacher, Gächter, and Fehr, 2001; Bolton and Ockenfels, 2000). Further, in addition to assuming that players may be other-regarding, a key assumption is that the “nature of the other-regarding capacity could differ from person to person” (Casari and Plott, 2003: 243).

Güth’s indirect evolutionary approach is an important theoretical step toward understanding how individuals, who do not maximize their own immediate payoffs, could survive in games with “rational egoists” who do pursue the predicted strategy (Güth and Kliemt, 1998). Güth has identified a key factor that facilitates the evolution of cooperative or fair behavior. This is the ability, on the part of the fair-minded types of players, to make contingent decisions (Güth and Yaari, 1992; Güth, 1995b; Güth, Kliemt, and Peleg, 2000). In other words, he and his colleagues have posited the existence of more than one type of player.

Brosig (2002) recently classified players using techniques developed by social psychologists (Liebrand, 1984; McClintock and Liebrand, 1988) into altruists (who maximized others’ payoffs), individualists (who maximized their own payoffs), and cooperative types (who maximized the sum of joint payoffs). In a four-player repeated public good game, Kurzban and Houser (2003) find three types of players: free riders (20% of their sample of their 84 subjects), unconditional cooperators (13%), and conditional cooperators (67%). They found that the strategies of these three types of players were stable across an initial round of plays as well as in an additional set of three games played after the first set was completed.

Assuming heterogeneity of types of players has recently become somewhat more accepted as scholars have tried to make coherent explanations of the extensive nonmarket experimental research conducted during the past two decades (Ostrom, 1998). As soon as one
assumes that multiple types of players exist, however, it becomes more difficult to predict how players will actually behave in the field or in an experimental laboratory. A key problem is that while one can assume that each individual knows their own type, how do they know the type of those with whom they interact in a laboratory or field setting? How does a conditional cooperator know he or she is interacting with other conditional cooperators? Do the internal weights of a utility function remain constant over time without regard to the type of situation that players are in or the behavior of others in a particular situation?

A consistent finding across experimental studies in common-pool resource and public good settings is that being able to engage in face-to-face communication is a major factor enhancing the proportion of individuals who cooperate, thus producing higher group payoffs (Ostrom and Walker, 1991; Ledyard, 1995; Orbell, van de Kragt, and Dawes, 1988; Kopelman, Weber, and Messick, 2002; Kollock, 1998). In a meta-analysis of more than 100 experiments, Sally (1995) finds that face-to-face communication significantly raises the rate of cooperation in two-person games. We speculate that there is something about face-to-face communication that increases the capacity of individuals to identify the types of players with whom they are interacting. This does not imply, however, that identifying the types or intentions of others in a group guarantees cooperation. Through a group discussion, a conditional cooperator may in fact detect that there are fewer conditional cooperators than originally thought and therefore adopt a strategy of not cooperating so as to avoid the bad payoff associated with unilateral cooperation among defectors.

For some time, scholars have been trying to sort out the various aspects of the communication process within experiments so as to understand better its impact (Dawes, McTavish, and Shaklee, 1977; Messick and Brewer, 1983; Dawes, van de Kragt, and Orbell,
1990). In a recent effort, Kollock (1998) summarizes the evidence for four factors that Messick and Brewer (1983) had earlier suggested as plausible reasons for communication to enhance cooperation levels. These are: (1) communication helps players detect the actions that others are most likely to take, (or, as we develop below, detect the types of players with whom they are interacting); (2) it allows players to make promises or commitments; (3) it allows a process of moralization among players; and (4) it can create or reinforce a sense of group identity.

Kopelman, Weber, and Messick (2002) review these potential explanations in the psychology literature and conclude that the hypothesis that group discussions tended primarily to elicit a commitment to cooperation had the most consistent empirical support (see also Kerr and Kaufman-Gilliland, 1994; Bouas and Komorita, 1996). Frank (1988) had speculated that the more cooperative types of players were also more likely to signal their type, as well as to recognize the type of other players with whom they are paired. Brosig (2002) confirms Frank’s speculations by first classifying players, then allowing them to communicate with each other, and finally asking them to predict the likely strategies of the other players.

Several scholars have stressed the importance of players being able to study each others’ faces as a key part of detecting their types. Scharlemann et al. (2001) and Eckel and Wilson (2003), for example, explored the reaction of individuals to seeing the face with whom they were supposedly interacting in a laboratory setting. Their results support the power of smiles as a mechanism to allow players to read the intentions of others and therefore to create trustworthiness. In their design there is no face-to-face communication, but information about facial expressions are used as treatment variables among strangers. They are able to explain variations in behavior within trust game situations and show that when players are shown pictures of smiling individuals, they respond with more trust and cooperation. Although the
pictures are not of the actual people with whom they are interacting, the facial expression does induce behavioral changes in ways that are consistent with the literature explaining how humans use such information to detect intentions by others (Frank, 1988; Schmidt and Cohn, 2001).

Bohnet and Frey (1999) explored whether it was what people said to one another or simply seeing one another that made a crucial difference to the level of cooperation in prisoner’s dilemma games. They found that communication is not always required to increase levels of cooperation. Silent identification of who would be involved in an experiment was by itself sufficient to increase the level of cooperation. They found that the variance in behavior was greater once face-to-face communication was substituted for silent identification prior to the experiment.

Other scholars who have been interested in separating out the communication aspect from the face-to-face aspect examined the impact of allowing people to communicate via computerized messages. Rocco and Warglein (1996) replicated the common-pool resource experiment of Ostrom, Gardner, and Walker (1994) and obtained very similar results when they allowed subjects to communicate on a face-to-face basis. On the other hand, allowing individuals to communicate via e-mail messages was much less effective in enhancing cooperation than allowing people to engage in face-to-face communication (see also Frohlich and Oppenheimer, 1998).

In another study, Bochet, Page, and Putterman (2002) compare face-to-face communication with the exchange of messages through computer terminals. Players had the opportunity to send messages to the rest of their group members, as numerical “possible” allocations or as verbal communication, followed by their actual decisions. The authors confirm the effectiveness of pre-play, face-to-face communication, but also find that the verbal and
anonymous chat room with open verbal exchange was almost as effective as the face-to-face case. They point out that the results are potentially in contradiction with the findings by Rocco (1998) and Frolich and Oppenheimer (1998), who find that e-mail communication was not as effective as the face-to-face exchange. Bochet and co-authors suggest that e-mail creates a different environment from that of a chat room with more difficult and slower feedback to be able to elicit intentions by other players.

Even after all of the speculation and previous empirical research, the role of communication in enhancing cooperation has not yet been fully explained, especially in more complex games involving more than two players. From conducting many dilemma experiments involving more than two players (and listening to the recorded tapes of, and reading the transcripts of, these experiments), we speculate that a great deal of the communication is devoted to two group tasks. The first task is problem clarification among the players. The second task is type-detection (see Simon and Gorgura, 2003, for an analysis of the content of the common-pool resource experiments conducted at Indiana University).

The first task of problem identification is nontrivial when more than two players are involved. Group discussions allow players to teach the confused players among their group about the structure of incentives and the trade-offs between individual and group outcomes that exist in a dilemma setting. Ostrom, Gardner, and Walker (1994: 151) suggest from the transcripts of their experiments that the discussions focused on determining the maximum possible yield and how to achieve it. Two of the main characteristics of the production function of common-pool resources, their partial excludability and partial subtractability, imply sometimes a complicated task for individual players. For instance, it can be the case that no dominant strategies exist regarding the level of individual appropriation. Therefore, the same individual
level could be either beneficial or harmful for group or individual outcomes. Figuring out the best group strategy, however, does not guarantee that players would pursue it since the incentives to deviate from group optimum are at the core of the dilemma.

The second task, we argue, is type-detection. Once subjects have used their communication time to figure out the structure of the situation and what would be the best joint outcome, they frequently turn to a discussion of what each person thinks everyone should do. They tend to make promises to one another by looking each other in the face as they are discussing their promises. Individuals begin to size up the trustworthiness and cooperativeness of the other individuals with whom they are situated and choose a best response accordingly.

McCabe and Smith (2003) suggest a cognitive model of goodwill accounting where players use a set of mental modules that allows players to gather information from the environment and from the other players to inform their decision to trust or reciprocate. One of these is closely related to the first task we suggest that groups accomplish through face-to-face communication, namely, to clarify the link between the subset of individual actions needed to obtain a group beneficial outcome. The other two modules in the McCabe and Smith cognitive model, the “friend-or-foe” and the “cheater detection,” are associated with our argument that group discussions allow individuals to update their accounting of the goodwill they may have received from the other players with whom they interact. Through these modules, each player gathers crucial information about the others’ intentions. Each play is also aware that if other players use the same modules, the player needs to send the correct signals so that the others’ goodwill accounting is updated according to the best strategy that optimizes payoffs for all. Otherwise, they will be perceived as a cheater and no goodwill will be extended.
However, there are a few particular conditions specific to the problem we are studying here, that is, groups sharing a common-pool resource worth highlighting. First, group size is almost always larger than two, which increases the complexity of the information processing about the others and about type-detection. Secondly, as in many social dilemmas, such process occurs within an environment of repeated rounds rather than in a one-shot game. Also, many of these situations involve a fixed group of players who interact through the game by having only a partial knowledge of the individual decisions made in previous rounds, usually observing only average or aggregate outcomes given the large personal costs of observing individual actions.

In this chapter, we will review evidence from recent experiments on common-pool resources conducted in the field to explore the existence of the mechanisms just described, and to illustrate the effectiveness of communication as an enhancing mechanism for cooperation. The features of the experimental design offer some particularities regarding the subject pool, the composition of the groups, and the institutional environments being compared.

II. EXPERIMENTAL DESIGN

The experiments reported here were conducted in villages in rural Colombia where participants were not only familiar with the use of common-pool resources—such as fisheries, water, or firewood—but knew each other and had a prior history of reputation building before the experimental sessions. Therefore, we can also assume that there would be a high probability of meeting with each other after the experimental session ended. This would make the use of type-detection and reading of intentions by players during the experiment more salient than when participants are total strangers, as in the case of college students where anonymity and
confidentiality of individual choices are common. Also, we expect greater heterogeneity of types in terms of rationality and familiarity with the task to be brought by participants.\footnote{For an example on how heterogeneity regarding the actual wealth and occupation of experimental subjects is used strategically in similar experiments in the field, see Cardenas (2003b). There it is shown that as the distance in wealth across group players increases, the levels of cooperation during face-to-face communication rounds decreases.}

Our experimental design is very simple. In a session of 20 rounds, each of five players in a group has to decide a level of extraction between one and eight units of a resource during two stages of 10 rounds each. We framed the situation as one in which individual households have to decide about the extraction level of a resource such as fish, firewood, or water. In each round, a monitor collected decisions and recorded them privately and confidentially. The monitor added the individual extraction levels and announced the total extraction for the group in that round. By knowing the group extraction and their own individual extraction, players were asked to calculate their individual earnings according to the payoff table\footnote{The table used by players works as follows. Each column corresponds to the individual level of extraction. Once the monitor has announced the total for the group, each player is able to subtract his or her individual extraction from the total to obtain “their level of extraction,” i.e., the row in the table, with which the player is able to realize earnings in that specific round. The values in the cells are based on a payoff function in which extraction increases individual earnings at a decreasing rate, and where group extraction reduces individual earnings at a linear rate, producing the typical common-pool resource dilemma as in the model used in the previous section. The values in the cells correspond to Col.$ pesos at an exchange rate, at the time, of about Col.$2700/1US.} (see Appendix). However, players did not know the individual decisions of the others in the group, just their aggregate extraction. This procedure was repeated for 20 rounds. At the end of all the rounds, earnings were added for each participant, and each was privately paid in cash.

In the payoff table, one observes that increasing one’s extraction yields higher individual earnings, but aggregate extraction decreases them, as is typical in any common-pool resource setting. Assuming a rational maximization of individual payoffs among material payoff-maximizers in a noncooperative game, the Nash equilibrium is located at the bottom-right corner.
of the table, where each player obtains 320 points. The social optimum occurs when all players choose one unit as their level of extraction, yielding 758 points for each player.

The data that follows were gathered in a series of 34 sessions conducted between 2000 and 2002 in different villages of Colombia where people depend in part on the use of a local ecosystem. Each experimental session was conducted with five participants, all of whom lived in the same village. Groups were randomly formed, but we avoided members of the same household to participate in the same session. We assume that the subjects in these field experiments would have some prior information about their neighbors in their session that they would likely use strategically in their decisions, namely, for detecting the intentions of the other four players.

II.1 Experimental Treatments: Baseline vs One-Shot vs Repeated Face-to-Face Communication

All 34 sessions were run in 20 rounds, split in two stages. After the instructions were read out loud and questions were answered, we started with at least one or two practice rounds. After the practice rounds, we initiated the experiment. During the first stage of ten rounds, all sessions were run under the same set of rules. The subjects were notified that the experiment would last at least ten rounds, and that during these rounds no communication among themselves would be allowed. The villagers were seated in a circle facing outwards so that the privacy of the decisions could be maintained. Once the ten rounds were over, the monitor announced that a second stage was about to start, under a new set of rules, for another ten rounds. None of the groups knew in advance during the first ten rounds the type of new rules for the second stage of the game.

We distributed the 34 sessions across three different treatment designs. For eight of the sessions, we used a baseline treatment where the second stage was run under the exact same
conditions, i.e., decisions were made privately and no communication was allowed among the players. This is our Baseline (B) treatment. For another 13 sessions, our One-Shot Communication (OSC) treatment, the subjects were allowed to have a single, face-to-face open discussion for five minutes before round 11, but none thereafter. They were asked to turn their seats 180 degrees so that they could see each other during the discussion time. Once the discussion had concluded, they had to turn their seats outwards again, and proceed with their individual, confidential decisions for the rest of the stage. These 13 groups were told in advance that such a discussion would happen only once before round 11, and that for the rest of the rounds they would make their private decisions under the same no-communication rule.

For the remaining 13 groups, our Repeated-Communication (RC) treatment, we replicated the previous design, but groups were allowed to have face-to-face communication before each of the rounds from 11 to 20. Players were still asked to turn around after their face-to-face discussions and to make their decisions in private at the end of each round. Table 1 summarizes the experimental design, sample sizes, and treatments.

[Table 1 about here]

II. 2. Conjectures about the Effects of Communication

The literature discussed in the introduction, supporting the effectiveness of face-to-face communication in experimental studies from psychology and economics, coincides with the overall finding that humans are more likely to cooperate in social dilemmas after communication among players, even under nonbinding agreements, and incomplete information about the individual choices of the others in the group. Which of the four mechanisms discussed in the introduction—detection of others’ actions, making of promises, moralization, or building of

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4 The open discussions did not allow them, however, to agree to transfer points or earnings once the experiment was concluded, replicating the work of Ostrom, Gardner, and Walker (1994).
group identity—induces cooperation or whether all four are important, however, is still unsettled. If communication induces changes in individual behavior, we should expect a significant change after round 11 in both experiments involving communication in comparison to the baseline treatment where no communication was allowed for all 20 rounds.

Regarding the OSC vs. the RC treatments, it is difficult to predict with precision what differences there should be during the second stage. Some of the mechanisms through which communication may work could enter in play from the very first round of communication and remain over time with no need for reinforcement. Others may require more than one group discussion. Earlier common-pool resource experiments did find one-shot communication substantially less effective than repeated communication (Ostrom, Gardner, and Walker, 1994).

In our experiments in the field, we observe that in addition to the four reasons that have already been posited for the efficacy of communication, the RC design allows participants first to clarify with each other the nature of the task and identify collectively the socially optimum solution. Only after the structure of incentives is clarified and the optimal solution is identified do participants appear to engage in some of the other mechanisms, such as group identity, verbal commitment to the others, and ultimately the attempt to detect what they expect the others to do in the following round.

III. EXPERIMENTAL RESULTS

This section reports the experimental results. In the following discussions, B denotes the baseline treatment in which no communication was allowed in any of the 20 rounds. OSC denotes One-Shot Communication treatment, in which a one-time communication was allowed between stages 1 and 2, that is, between rounds 10 and 11. RC denotes Repeated Communication treatment in which communication was allowed before each round of stage 2.
Figure 1 plots the average levels of extraction in the three treatments with 95% confidence intervals. Confidence intervals are shown to help readers see whether the differences in average levels between two treatments are significant; if two confidence intervals for a given round overlaps, the difference is not significant at the 95% confidence level. The average extraction levels in the B treatment are marked with circles, those in the OSC treatment with rectangles, and those in the RC treatment with triangles. As the figure shows, the averages extraction levels in the first stage (rounds 1 to 10) are very close to one another and are not significantly different from each other. Thus, the confidence levels are shown only for the second stage, where the differences are more pronounced.

Figure 1 shows that the average behaviors in different treatments are generally consistent with our conjectures outlined in the previous sections. That is, communication does help reduce the extraction level and achieve higher levels of efficiency. Furthermore, repeated communication is more effective than one-shot communication. As the confidence intervals illustrate, however, substantial variance exists across sessions of each treatment. Appendices A-2 to A-4 present the average extraction levels in each session. Notice, in Figure 1, that the average extraction levels in all three treatments are above the socially efficient level of 1, but well below the equilibrium prediction of 8.

Table 2 provides the results of Wilcoxon rank-sum difference of means tests for selected pair-wise comparisons of average group-level extraction. We are comparing here the average group extractions rather than individual levels of extraction. For example, the first row shows that the average per-round group-level extraction in the final three rounds of stage 1 is 22.08 in
the B treatment and 23.04 in the OSC treatment. The p-value of 0.7720 in the last column indicates that these two averages are not significant.

We have chosen to compare the average group-level extraction in the final three rounds of stage 1, the first three rounds of stage 2, and the final three rounds of stage 2. There are many other candidates for comparison, but we have chosen these three segments for the following reasons. First, the average extraction levels in the final three rounds of stage 1 are compared to see whether the groups in different treatments are truly comparable. That is, it is possible that different treatments were accidentally assigned to groups with different characteristics. If this were the case, differences across treatments in stage 2 would not be due to different levels of communication, but rather due to the differences of group characteristics that are irrelevant for our research purposes. Second, the first three rounds of stage 2 are chosen to see the immediate effect of communication compared to the non-communication environment in stage 1. Third, the final three rounds of stage 2 are chosen to see the long-run effects of one-shot and repeated communication.

As the first set of three comparisons shows, there were no differences across treatments at the end of the first stage. We obtained the same results when we tested the significance of differences in round 10 only or for all 10 rounds of stage 1. The second set of tests shows that communication generated immediate positive effects. That is, both the groups in OSC and RC reduced their extraction levels significantly compared to the groups in the B treatment. The difference between OSC and RC was not significant at all (p=0.9386). The third set of comparisons shows that in the long run, only the groups in RC treatment were able to sustain the reduced levels of extraction. That is, the extraction level of the groups in OSC increased over time such that the difference in the average group-level extraction between B and OSC is no
longer significant towards the end of stage 2 (p=0.1110). The groups in RC treatment, however, were able to sustain the lower levels of extraction over time. In fact, not only is the average group-level extraction of RC in the final three rounds of stage 2 significantly lower than that in B (p=0.0007), it is also significantly lower than that in OSC (p=0.0723).

[Table 2 about here]

While Table 2 shows the difference across treatments, there are variations across groups in each treatment (see Appendices A-1, A-2, and A-3). In particular, it is worth noting that the effects of one-shot communication and repeated communication manifest in different ways in different groups. Thus, while the average group-level extraction increased over time in OSC, some groups were able to maintain or achieve very low levels of extraction (see groups VCX13 and VCX15 in Appendix A-3, for example). Similarly, while the average group-level extraction across groups in RC was significantly lower than those in B or OSC, some groups in RC achieved mutual cooperation immediately after communication was allowed and maintained the beneficial mutual cooperation successfully over time (see groups GCX5_t1 and PCCX5_t3 in Appendix A-4, for example). It then took several rounds to reduce the extraction level for other groups (group CHCX5_t1 in Appendix A-4, for example). Still other groups were not quite successful in maintaining consistently lower levels of extraction even with repeated communication (see groups GCX5_t21 and PPCX5_t2 in Appendix A-4, for example).

On average, however, outcomes in the RC treatment groups were more efficient than in the OSC treatment groups. Although in both treatments all groups reduced their extraction level in round 11, groups in the OSC treatment increased the extraction levels over time after the initial communication. By the end of the second stage, the average group extraction in the OSC treatment was about four units higher than that in the RC treatment, although it was still almost
ten units below the group extraction in the B treatment. When comparing the extraction levels in the beginning and at the end of the second stage in each treatment, we find that only the OSC treatment shows a trend (from low to high,) while the B treatment shows consistently high levels of extraction over the rounds and the RC treatment shows consistently low levels of extraction over the rounds.

A more detailed look at the change in decisions by players over time provides us with the information about the underlying individual-level behavior that resulted in the group-level patterns over time. In Figure 2, we present histograms of the fraction of individuals with different extraction levels, by round and by treatment for the second stage of the experiment. The first columns of the histograms show that the extraction levels in the baseline treatment are spread widely between the minimum of 1 and the maximum of 8 in each of the 10 rounds.

On the other hand, the distribution of extraction levels in OSC treatment is initially skewed toward lower levels, implying that most players chose to cooperate with others immediately following the one-shot communication. Over time, however, many low extractors switch to medium- or high-level extractions. Thus, by the final rounds of the second stage, the distribution is much flatter than that in the initial rounds. The third histograms of the column show that the distribution remains skewed over time. That is, the switch made by initial low-level extractors to high-levels of extraction did not happen in the RC treatment. The distribution pattern in OSC is closer to that in RC in the initial rounds, but becomes more similar to that of B over time.

The initial similarity and subsequent divergence between OSC and RC indicates that the differences after round 11 between the two treatments are less likely due to the effects of communication on clarifying group incentives (what is best for group?), but rather due to the
effects of communication on signaling and reinforcing cooperative intentions and behavior. We have also argued that type-detection should be more effective during the RC treatment than with the OSC treatment. In the OSC treatment, a player would construct a preliminary distribution of types and would not have further information after each subsequent round to update this estimated distribution about the other four group members. This creates a higher error in detection of types than in RC, where players improve their estimate over rounds. Watching facial expressions, as well as hearing the discussions, allows players to compare commitments in the previous round with average outcomes obtained in that round and therefore update their estimates.

Our experiments involve people in villages who face the common-pool resource problem on a daily basis, providing one way of testing the external validity of earlier common-pool resource experiments utilizing undergraduate students. Running experiments in the field also presents challenges for the researcher. The fact that each of the groups is composed of five people from the same village implies that pre-play and ex-post incentives may come into play. Cardenas (2003a) discusses these elements in detail and suggests that there are valuable lessons that can be learned when one takes into account the village-specific conditions.

One exercise with the current data illustrates some of these issues. As shown in Figure 1 and the Appendices, groups in the same treatment show large variances among them. This variation across groups persists during the second stage and shows that even within treatments, some groups were able to achieve substantially higher levels of cooperation than others. What accounts for this within-treatment variation? We conjecture that part of the reason is the heterogeneity of types and the particular composition of each group. It is reasonable to assume that each subject in a group had prior information about the other four players in a group—a
significant difference from the typical experiments with student subjects—acquired during their daily interactions with others in the village. Thus, we hypothesize that the baseline composition of different types in each group was more or less known to each member of a group and this knowledge, in turn, generated correlation between group members’ behavior in the first and second stages.

To test this, Figure 3 plots the correlation between the average extraction level in the final three rounds of the first stage (rounds 8 to 10) and those in the final three rounds of the second stage (rounds 18 to 20) for each of the 34 groups. Groups in the B (OSC, RC) treatment are marked by circles (rectangles, triangles) and the Pearson correlation coefficients are calculated for each treatment. The figure and the correlation coefficients suggest that, particularly for the B and OSC treatments, the variation in the levels of cooperation at the end of the second stage can be explained by the level of cooperation at the end of the first stage. Notice that even in the absence of communication, some groups in the B treatment maintain low levels of extraction in both the first and second stages. We interpret the high correlations between the behavior in the first and second stages as evidence that subjects in the field experiments brought into the lab knowledge about the composition of types in a group and their likely behavior.

[Figure 3 about here]

Though not reported in this chapter, a replication of the current experiment utilizing student subjects did not show the levels of correlation between the behavior in the first and second stages. The experiment did, however, replicate the positive effects of communication in both the OSC and RC treatments. The fact that in experiments with villagers, group behavior in

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5 A multiple regression using the average levels of extraction in rounds 8 to 10 for each group as the dependent variable, with the independent variables being the average level of extraction in rounds 18 to 20 and dummy variables for the particular treatment as independent variables, generates a positive and significant coefficient. The adjusted R square value for the regression is slightly higher than 0.5.
the first stage can explain group behavior in the second stage, while that is not the case in experiments with student subjects, indicates that our subjects in the field used information they had about the types of others in the group that they brought into the experiment.

IV. COMMUNICATION AND COOPERATION: A LOOK AT THE TRANSCRIPTS

We speculated earlier that at least two tasks are accomplished when players communicate with each other. First, a group discussion allows the subjects to clarify the nature of the dilemma and to make explicit agreements about group-oriented goals, in this case, that lower levels of extraction yield higher individual and group returns. The second task we posited is type-detection which we discuss below.

With a nonlinear functional form and five players, it can be a confusing task for some of the participants to figure out for sure what is the optimum strategy for them to pursue. In such a setting, participants need to discuss alternative strategies to determine the best strategy available to them. Examples from the transcripts of the audiotapes during the first round of communication for several groups illustrate how they pursued this task. In this dialogue between two players during the opening of the first round of communication, one of them explains the nature of the relation between total extraction level and individual earnings, while the other begins to understand the dilemma:

*Player 1:* …We run out of points, but we end up with more earnings if at least, let’s say, we choose 1, it adds to 5; another example we all play 2, it adds to 10, so you think, say, about choosing 2.
*Player 2:* Number 2…
*Player 1:* …Then 10 minus 2 equals 8.
*Player 2:* 8.
*Player 1:* Then by choosing 2, it yields more points the lower numbers we choose.
*Player 2:* The lower our number, more points we get.
*Player 1:* Let’s put that number here,…there, more points this way.
*Player 2:* Yes, so that we….
*Player 1:* It is better to get more points, the more points the better, the lower the points we choose, the number right here will favor us in the table there.
In another village where shrimp-fishing is very common, we observe a similar pattern in the opening round of group discussion. Further, notice the metaphor they use for the first round of group discussion when referring to fishing in kilos (kilograms) as the units of extraction in the experiment:

PLAYER A: 2 kilos.
PLAYER B: Tomorrow I am going to fish 2 kilos.
PLAYER C: Tomorrow, 1 kilo.
PLAYER A: Well, my thing is to be in agreement, that is, with the word of my friend here, if you know what I mean; to me, let us catch a kilo each so that it does not turn scarce later on, and then with pleasure it is good to come back the next day and catch another kilo and that way we don’t run out of shrimp; if we catch 5 or 4 kilos the next day we go out there and there is no more; so, to me, I say we catch a kilo each.
PLAYER B: Yes, that’s the way, easy so that it stays good, that’s the idea, the gasoline.
PLAYER C: …And then, when the kids tomorrow go fishing they will have their chance to catch a kilo each, otherwise look how we are now.
PLAYER A: We all agree.
Several players at same time: yes, don’t worry.

In this second case, the group discussion allowed the players to relate the exercise to their own shrimp-fishing activity and easily find a strategy that will make sense regarding the need for extracting small quantities of the resource to yield higher returns to the players.

In the other sessions for which we have audio recordings, we observe a regular sequential pattern during the conversations. The pattern could be described as a sequence of the following steps for building an effective agreement for cooperation:

1. Identification of the goal for the group and clarification to all group members that a lower level of aggregate extraction can increase individual earnings. In most cases, one or two players make these comments.

2. An agreement or ratification of the need for every player to choose a low level of extraction. In several cases, it was as explicit as agreeing that one unit per player
would achieve the maximum earnings for the group. In other cases, it was more frequent to observe agreements like “low numbers for extraction.”

This pattern occurred for most sessions during round 11 in the second stage under communication. The first round of discussion usually focused primarily on these first two elements. We found no reference to the detection of types during the first round of group discussion.

However, during the next rounds (12-20) for those groups that were allowed repeated communication in the RC treatment, we observed at least two more steps or kinds of interventions by players:

3. Reinforcement of an agreement that members had previously made. In several cases of repeated communication, we observed a permanent call by some in the group to maintain a low level of extraction. Others brought up the comparison of rounds with higher and lower yields in the payoffs table, or how detrimental it was for the group that one player increased his or her extraction to obtain higher payoffs.

4. Discussions about types and type-detection strategies. Often, some players would argue that total extraction was high in previous rounds, and that somebody was probably increasing his or her level of extraction, causing damage to the rest of the group. For some groups, such a call was at moments directed at someone in particular, usually when group members knew each other well.

For the latter case, we could observe examples like the following dialogue in one of the sessions under repeated communication:

PLAYER X: The idea, the idea is that we all choose 1 in all rounds, I think that.... We are all expecting to make some gains here.

PLAYER Y: Of course!
PLAYER X: Therefore everybody gets together... That means there is no God, as long as no one breaks the trust.
PLAYER Z: The thing is trusting the other.
PLAYER Y: No, I'm all set.
PLAYER X: That is, we all know each other, no not knowing others, no one wants to partner with no one, so that everyone chose 1 and that’s it, that’s it.
PLAYER Y: Ha, ha, yes.
PLAYER Z: It is like a mirror work.
PLAYER Y: Beware!.. it makes me giggle, I know that after a while ...I’m going to be one of those....
PLAYER X: Look, if anyone cheats now that we start adding the group total...
PLAYER Y: We will end up knowing...
PLAYER X: It is going to be right here, at the moment when the total adds to more than five, at that moment someone cheated.
PLAYER Z: Someone...
PLAYER X: ...At that moment we will know, and well, we will understand
PLAYER Y: We will know that...
PLAYER X: We will know that...anyway, well, let’s choose 1 and that’s it, and we all gain and ready.
PLAYER Y: Listen....
PLAYER X: The sum will have to be 5 always.

In this case, they gave each other several warnings on how easy it would be to detect if someone had cheated from the initial agreement of each choosing one unit for a group total of five units. By stressing an ethical responsibility for each player, the absence of a God, and the importance of trust, they were stressing their expectations that others would keep the agreement and, if not, that they would know who defected. In fact, days after the conclusion of the sessions, and because the experimenter usually holds workshops with the community members to show preliminary results and discuss parallels with their actual common-pool resources, we observed that many participants had already identified who from the different groups acted more selfishly during the experiments even though care is taken to make payments in private.

V. CONCLUSION

We have approached the problem of cooperation in common-pool resource dilemmas by first exploring the role of face-to-face communication in a repeated game setting. We posit that
communication helps players choose a strategy that improves their payoffs above those predicted by the conventional model of a Nash equilibrium. The consistent finding is that face-to-face communication has a powerful effect on increasing trust and cooperation in experimental settings. As we discuss in the Introduction, a complex set of factors affects likely outcomes. Group identity, reputation building, creation of normative feelings, fear of social ostracism, and the emergence of commitments are examples of factors explaining why communication works. We suggest that communication also helps players improve their capacity to detect the types of other group members.

In the experiments presented here, we allowed villagers from the same community to engage in a face-to-face discussion during the second stage of a common-pool resource situation. This gave the players, we argue, an opportunity to update their priors about the types of players within their groups and choose their extraction level accordingly. As discussed in our model, better type-detection does not guarantee greater levels of cooperation. Detecting a sufficiently large number of rational egoists in a group will induce conditional cooperators to act as egoists to reduce their losses if they were to act cooperatively. In fact, in a few groups, the levels of cooperation achieved during the repeated communication rounds were low while they were very high for most others. Further, there might be information players had about their fellow group members carried over from their earlier experience with each other that might have played a role in their decisions during the second stage, once the group had agreed on a strategy for increasing aggregate earnings. This was the case not only for some groups under OSC but also for RC, as shown in the individual sessions’ graphs in the Appendix.

Nevertheless, on average, communication helped groups to reduce total extraction and to increase group and individual earnings. The gains were much higher if the communication was
repeated. In the OSC treatment, we found no reference in the recorded discussions to detection of intentions by individual players in the discussions at round 11. The feedback in every round about group outcomes, and the face-to-face interaction, helped players create a better accounting of the types in the rest of the group.

Given the short duration of the experiment, it is not very likely that some subjects actually changed their types. What is more likely to have happened is that communication made it common knowledge that there are conditional cooperators in a group. Game-theoretic models show that when there are conditional cooperators, egoists have incentives to cooperate until near the end of a repeated game (Kreps et al., 1982). Communication plays two roles in this context. First, it allows conditional cooperators to express their intentions. Announcing their preferences may be regarded as cheap talk. But there is evidence that humans do a pretty good job in judging whether someone is telling the truth (see Ahn, Janssen, and Ostrom, 2003, for a review of the literature). Brosig (2002) explores how individuals are capable of recognizing the types and how such recognition and signaling of one’s own type help, particularly cooperators, to detect the type of their anonymous partner. Further, she finds that pre-play communication induces not only cooperators but also individualistic types to act cooperatively and therefore increase the gains from social exchange.

Once the existence of conditional cooperators becomes common knowledge, there still remains the problem of equilibrium selection among all players. That is, even with a substantive proportion of conditional cooperators, universal defection is still an equilibrium. Players need to be convinced that others would cooperate and that others also think that a sufficient number of other group members would cooperate, etc. (Chwe, 2001). That is, in addition to the existence of the conditional cooperators, the play of cooperative equilibrium also needs to be established as
common knowledge. Repeated face-to-face communication is the most effective means of achieving such common knowledge, as the increased rates of cooperation in repeated communication setting of the reported experiment show.

Further work will follow. Separating type-detection from other confounding effects at work under communication is a natural next step in our research. Also, classifying individual decisions data into the three types we discuss will provide some light on how group cooperation may emerge and be sustained under different rules or institutional environments. Individual-level data in many of these experiments show that players change their strategies over time within the same session. The evidence from these experiments in the field, while not directly testing preference evolution, is consistent with two necessary assumptions of Güth’s indirect evolutionary approach: first, that conditional cooperators exist; second, that they engage in efforts to detect the presence of other conditional cooperators. Communication is one of the major techniques for group dynamics to emerge, leading to higher levels of cooperation in dilemma and trust games when there are multiple types of players. Repeated face-to-face communication helps to establish the existence of conditional cooperators in a group who can then develop common knowledge that they will play the cooperative equilibrium in a repeated game.
REFERENCES


FIGURE 1. Average extraction over rounds (Baseline, One-Shot, and Repeated Communication)
FIGURE 2. Distribution of decisions by treatment over rounds (second stage, rounds 11-20)

<table>
<thead>
<tr>
<th>Round</th>
<th>Baseline (B)</th>
<th>One-Shot Communication (OSC)</th>
<th>Repeated Communication (RC)</th>
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<td>Round 11</td>
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FIGURE 3. Average group-level extraction at the end of the 1st and 2nd stages, by treatment
TABLE 1. Treatments, designs, and sample sizes

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Number of Sessions</th>
<th>Number of People</th>
<th>Stage 1 (10 rounds)</th>
<th>New Rule</th>
<th>Stage 2 (10 rounds)</th>
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</thead>
<tbody>
<tr>
<td>(B) Baseline</td>
<td>8</td>
<td>40</td>
<td>$X_1, X_2, \ldots, X_{10}$</td>
<td>(No change - control)</td>
<td>$X_{11}$, $X_{12}, X_{13}, \ldots, X_{20}$</td>
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<tr>
<td>(OSC) One-Shot Communication</td>
<td>13</td>
<td>65</td>
<td>$X_1, X_2, \ldots, X_{10}$</td>
<td>1 face-to-face group discussion ($t=11$ only)</td>
<td>$(C-X)<em>{11}$, $X</em>{12}, X_{13}, \ldots, X_{20}$</td>
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<tr>
<td>(RC) Repeated Communication</td>
<td>13</td>
<td>65</td>
<td>$X_1, X_2, \ldots, X_{10}$</td>
<td>Face-to-face communication before each round decision</td>
<td>$(C-X)<em>{14}$, $(C-X)</em>{12}, (C-X)<em>{13}, \ldots, (C-X)</em>{20}$</td>
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<tr>
<td>TOTAL</td>
<td>34</td>
<td>170</td>
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### TABLE 2. Pair-wise comparisons of average group extraction levels

<table>
<thead>
<tr>
<th>Rounds</th>
<th>Treatments Compared</th>
<th>Average Group Extraction</th>
<th>P-values</th>
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<tbody>
<tr>
<td></td>
<td>B vs. OSC</td>
<td>22.08 vs. 23.04</td>
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<tr>
<td>8 to 10</td>
<td>B vs. RC</td>
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<td>OSC vs. RC</td>
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<td>B vs. OSC</td>
<td>23.25 vs. 13.85</td>
<td>0.0030</td>
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<tr>
<td>11 to 13</td>
<td>B vs. RC</td>
<td>23.25 vs. 13.51</td>
<td>0.0030</td>
</tr>
<tr>
<td></td>
<td>OSC vs. RC</td>
<td>13.85 vs. 13.51</td>
<td>0.9386</td>
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<tr>
<td></td>
<td>B vs. OSC</td>
<td>24.04 vs. 17.63</td>
<td>0.1110</td>
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<tr>
<td>18 to 20</td>
<td>B vs. RC</td>
<td>24.04 vs. 12.56</td>
<td>0.0007</td>
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<tr>
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<td>OSC vs. RC</td>
<td>17.63 vs. 12.56</td>
<td>0.0723</td>
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</table>

Note: B = Baseline treatment with no communication; OSC = One-Shot Communication; RC = Repeated Communication. Number of observations is equal to the number of groups in each treatment: 8 in B, 13 in OSC, and 13 in RC.
APPENDIX

A-1. Payoffs table experimental design

<table>
<thead>
<tr>
<th>THEIR EXTRACTION LEVEL</th>
<th>MY LEVEL OF EXTRACTION</th>
<th>Their Average Extraction</th>
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A-2. Individual sessions data

Group extraction (SumX) by session (B, Baseline treatment)

Graphs by GROUP
A-3. Group extraction (SumX) by session (OSC, One-Shot Communication)

ROUND
Graphs by GROUP
A-4. Group extraction (SumX) by session (RC, Repeated Communication)